PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in and relating to the Reversal of Ships Driven with Electric Machines

We, AKTIENGESELLSCHAFT BROWN, BOVERI & CIE., of Baden, Switzerland, a Swiss Company, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The equipment of a ship driven with electric machines consists nowadays mostly of a power installation, in which synchronous polyphase generators are driven by steam turbines or Diesel engines, and of one or more polyphase synchronous motors which, when the ship is travelling ahead in the normal manner, work as synchronous machines, but, when it is travelling astern, as asynchronous machines. The damper winding, with which these machines are provided, then serves for taking up the secondary currents. During starting and reversing it must not become excessively hot and must therefore be made sufficiently thick.

In order to save this winding as far as possible, it has already been proposed so to carry out the actual slowing down procedure of the ship that the stator winding of the synchronous motor is connected with a slowing down resistance. On the rotating field system of the machine being excited, it will act as a generator on this resistance. The energy which it requires for this purpose it must take from the propeller shaft, in other words the speed of revolution of the shaft is thereby reduced with respect to that imparted to it by the travelling ship and the ship will be slowed down.

The object of the invention is to provide a ship's drive of this character having improved properties as regards slowing down and reversing the ship.

The invention consists in an alternating current synchronous electrical drive for ships wherein, in addition to the usual means for slowing down the ship by separating electrically the generator and motor and causing the motor to act as a generator on a load circuit, means are provided for (a) reducing the generator speed to a predetermined value, (b) de-energising the generator and motor field circuits when the speed of the ship has fallen to a predetermined value, (c) disconnecting the load circuit from the motor shortly after the de-energisation of the generator and motor field circuits, (d) connecting the generator with reversed phase sequence to the motor and (e) controlling the excitation of the generator or of the motor or of both.

The invention further consists in an electrical ship's drive according to the preceding paragraph, wherein the motor is capable of operating both in a synchronous or in an asynchronous manner.

The invention further consists in an electrical ship's drive according to either of the two preceding paragraphs, wherein the means for reducing the generator speed is constituted by the regulator of the supply of driving medium to the prime mover associated with the generator.

The invention further consists in an electrical ship's device according to any of the three preceding paragraphs, wherein the load circuit of the motor, when the latter is acting as a generator, has a fixed value or is variable in a few large steps.

The invention further consists in an electrical ship's drive constructed and operated substantially as described with reference to the accompanying drawings.

When operating according to the invention, on the slowing down procedure being initiated, first of all the machines are de-energised and the power installation and the synchronous motor are electrically separated from one another; the stator of the propeller motor is thereupon connected to a resistance and its field system energised; as soon as the speed of travel of the ship has dropped to a fraction of the normal speed, the generator of the power installation, which has been regulated down in its speed of revolution, is connected with the sequence of phases reversed to the de-energised propeller motor, so that a slowing down by reverse current will first take place, until the ship comes to rest and thereupon immediately reverses its direction of travel. While the generator is disconnected it is preferable to set the speed regulator of the power

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installation machine to that low speed of revolution or network frequency, at which it is intended to start up the propeller motor again, so that the speed of revolution of the set will drop. The generator may be either energised or not energised. By separating the power unit and the propeller motor the magnitude of the slowing down resistance is limited as compared with the slowing down procedure with connected up generator, which is also possible, as the resistance has to absorb only the slowing down energy of the propeller shaft and not that of the power installation machine. The kinetic energy of the latter is utilised to better advantage; it serves the purpose of causing the speed of revolution of the set which is working without steam admission to drop slowly and may in certain circumstances even be consumed during the restarting of the propeller shaft.

In the accompanying drawing a simplified diagram of connections is shown, with reference to which the new method will now be described in detail. For slowing down, the source of exciter current *e* is first disconnected by means of the circuit breaker *f*, and thereupon the main switch *h* between the generator *g* and the propeller motor *m* is opened. This causes the speed of revolution of the propeller *p* to drop to the idle running speed, the speed of travel of the ship remaining practically undiminished. For slowing down the ship the resistance *w* is then connected by means of the switch *s* to the terminals of the motor *m* and the latter is excited by closing the switch *f*, the field being, if required, adjusted at the regulator *r*. The motor *m* will then, driven by the propeller *p* running as a turbine, operate as a generator on the resistance *w* and this additional work performed by the travelling ship will retard its speed of travel. In the meantime the speed of revolution of the generator *g* running idle in the excited or re-excited state will have been reduced through the driving medium regulator of the turbine *t* being adjusted to the value, at which it is intended to reconnect the motor *m*, and the phase changing switch *u* is changed over. When that fractional part of the speed of travel of the ship is reached, at which it is intended to reverse, and which suitably amounts to one half or one third of the normal speed of travel of the ship, the excitation *e* of the motor *m* and the generator *g* is disconnected by means of the switch *f*, the resistance switch *s* is opened, the main switch *h* is closed and in the first place only the excitation of the generator switched on at *f* is increased by means of the regulator *v*, whilst the excitation of the motor *m* remains unaltered by returning the regulator *r* into the zero position. The motor will then run asynchronously with the aid of its damper winding, at first in opposition to its rotating field, but will later reverse its direction of rotation, owing to the diminishing hydraulic resistance, the ship being thus considerably slowed down. The motor *m* now runs in the direction of rotation of travelling astern and, as soon as it has arrived in the vicinity of synchronism is excited, so that it can now be brought easily into synchronism. When it is running synchronously, the frequency of the generator *g* can be again increased by means of the turbine regulator and the astern motion of the ship can be accelerated.

The slowing down effect of the synchronous motor *m* can be adjusted with the magnitude of the slowing down resistance *w* and with the degree of excitation at the regulator *r*. When these two regulating means are correctly employed, both the maximum value of the torque of the slowing down machine and the position of the torque curves can be optionally selected in dependence on the speed of revolution of the propeller. When the magnitude of the torque is known, which the propeller exerts on the shaft at a definite speed of travel of the ship and at a definite speed of revolution of the shaft, it is possible, by a suitable adjustment of the resistance and of the excitation, to cause the propeller very rapidly to assume a very low speed of revolution at which its slowing down force on the travelling ship is considerable.

In order to make the drive simpler to operate, it is preferable in certain circumstances not to regulate the resistance finely, but to provide only a few steps or only a fixed resistance, that is to say one very coarse step. When the resistance has once been correctly adjusted, there is in general no necessity to alter it during the slowing down procedure. The more the speed of travel of the ship eases, the more will the speed of revolution of the shaft drop automatically. It may be desirable to provide means for enabling the terminals of the synchronous motor to be directly short-circuited as well, as is indicated in the drawing by the switch *k*.

The power, with which in the described slowing down method the speed of travel of the ship is slowed down by the water, decreases rapidly with the decreasing speed of travel of the ship. As this power is taken from the kinetic energy of the moving ship, of which it is desired to relieve the ship, the result is, that the speed of travel of the ship will during the

slowing down procedure at first diminish rapidly and then more and more slowly. As however it is of importance to bring the ship to rest with as short a run out as possible, it would be unsuitable to retain the described slowing down connections for too long a period. For this reason the reversal of the propeller motor will preferably be already effected, when the speed of travel of the ship has reached half to one third of its initial value, which can be determined from the speed of revolution of the propeller motor *m* or its current.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. An alternating current synchronous electrical drive for ships wherein, in addition to the usual means for slowing down the ship by separating electrically the generator and motor and causing the motor to act as a generator on a load circuit, means are provided for (a) reducing the generator speed to a predetermined value, (b) de-energising the generator and motor field circuits when the speed of the ship has fallen to a predetermined value, (c) disconnecting the load circuit from the motor shortly after the de-energisation of the generator and motor field circuits, (d) connecting the generator with reversed phase sequence to the motor and (e) controlling the excitation of the generator or of the motor or of both.

2. An electrical ship's drive as claimed in Claim 1, wherein the motor is capable of operating both in a synchronous or in an asynchronous manner.

3. An electrical ship's drive as claimed in Claim 1 or Claim 2, wherein the means for reducing the generator speed is constituted by the regulator of the supply of driving medium to the prime mover associated with the generator.

4. An electrical ship's drive as claimed in any of Claims 1 to 3, wherein the load circuit of the motor, when the latter is acting as a generator, has a fixed value or is variable in a few large steps.

5. An electrical ship's drive constructed and operated substantially as described with reference to the accompanying drawings.

Dated this 30th day of November, 1938.

MARKS & CLERK.

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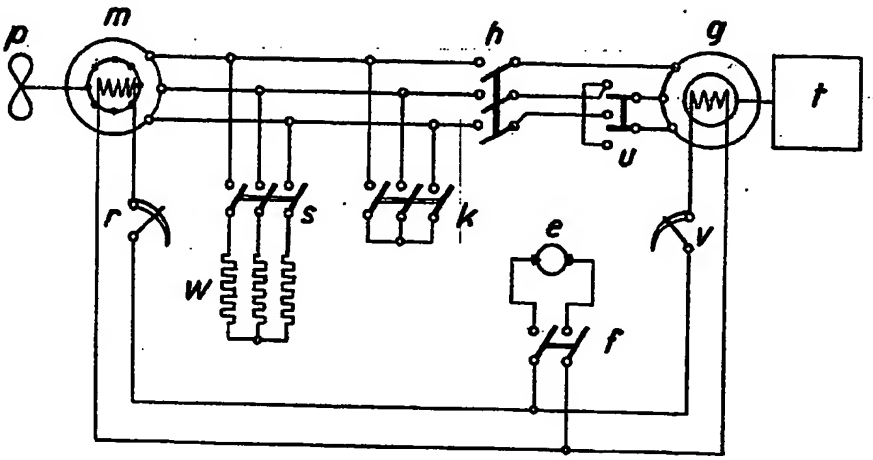

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